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Regional and temporal parasite loads in bumble bees associated with cranberry landscapes

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Regional and temporal parasite loads in bumble bees associated with cranberry landscapes

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Abstract

There are concerns that the fitness of bumble bees that provide pollination services to cranberry could suffer within intensively managed agricultural lands. In the cranberry region of Massachusetts, the crop occurs within urbanized coastal and sand plains that generally lack floral resources. Additional stressors that compromise the health of bumble bee colonies could be the reduction of habitat and infections by parasites. In contrast to the lack of floral resources in the region, the mass bloom of managed cranberry provides abundant floral resources around July. We examined the prevalence and intensity of pathogen infection in bumble bees collected across areas of varying cranberry bloom. To determine how the amount of cranberry acreage affects the prevalence of these parasites, bumble bee queens and workers of multiple *Bombus spp*. were assessed for parasite presence and load. The amount of cranberry bog within 2 km of each collected bee was calculated and included in a model testing its effect on parasite prevalence and intensity. Initial investigations appeared to show higher prevalence and intensity of the trypanosome *Crithidia bombi* in areas with little to no acreage of cranberry bog in comparison to areas with higher acreage of cranberry. This did not hold true for *Nosema bombi*, *Apicystis bombi*, and parasitism by conopid flies. We speculate on the reasons behind our findings, including the potential effects of fungicide use and phytochemicals on the health of bumble bees.

Objectives

- Quantify the number of bumble bees that are parasitized by *Crithidia bombi*, *Nosema bombi*, *Apicystis bombi,* and conopid flies and determine their level of infection.
- Determine the amount of cranberry acreage around each collected bee and how this relates to the prevalence of parasitism and intensity of infection.

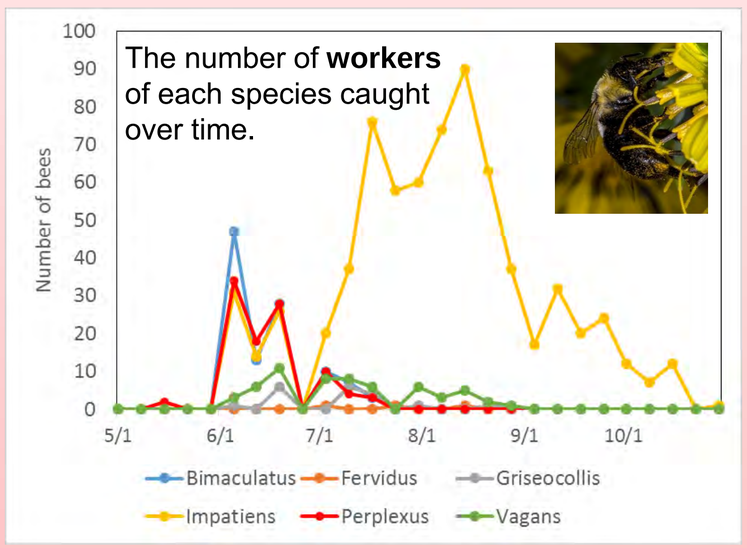
What we did (in brief)

Queens and workers collected and assessed for parasites.

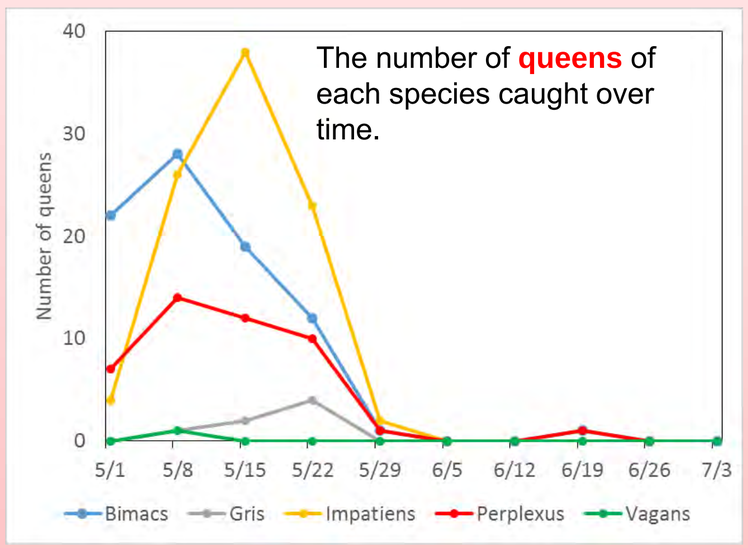
Investigate infection among species and over time.

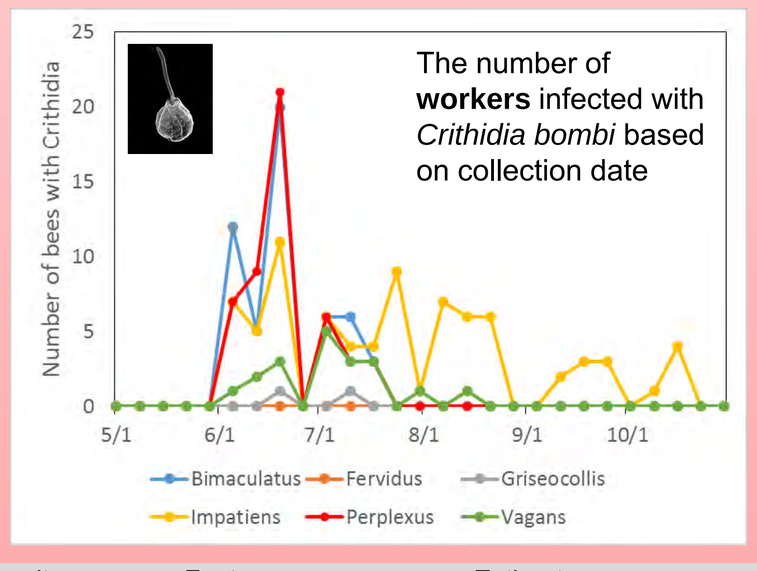
Logistic regression to test relationship between cranberry acreage and parasite prevalence and intensity.

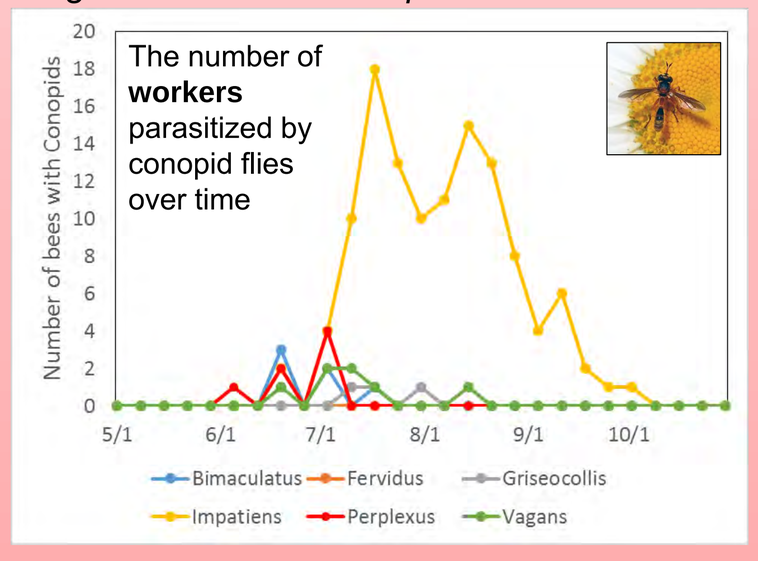
What we found

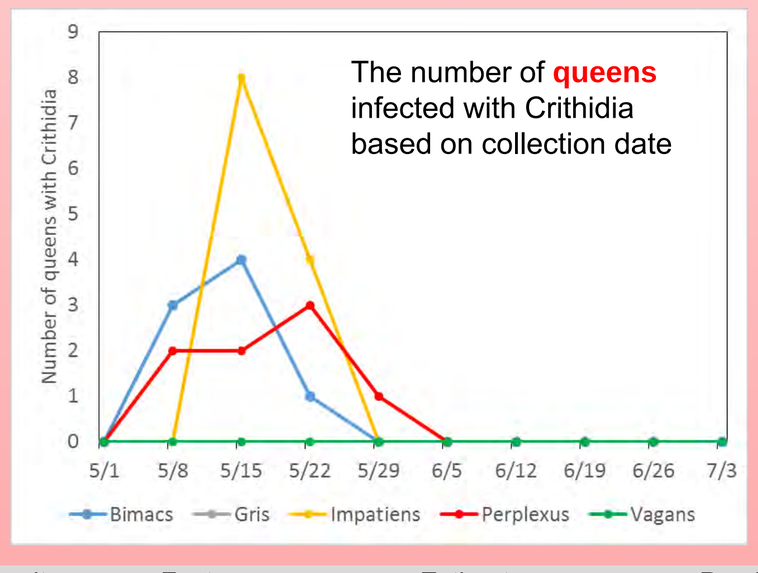


- The majority of our collection was comprised of *Bombus impatiens* with low levels of *Bombus fervidus, Bombus griseocollis, and Bombus vagans*.
- *Bombus fervidus* queens were not found.
- Parasitism by *Nosema bombi* and *Apicystis bombi* is relatively low among all species.
- Parasitism by conopid flies appears to be aligned with *Bombus impatiens* collections.









Parasite	Factors	Estimate	z-score	P-value
Crithidia bombi	**Cranberry acreage**	**-0.017**	**-2.753**	**<0.001**
	Date of catch	-0.007	-1.976	0.048
	Bombus griseocollis	-1.779	-2.269	0.023
	Bombus impatiens	-1.692	-5.959	<0.001
Nosema bombi	Cranberry acreage	-0.003	-0.358	0.720
	Date of catch	0.019	3.923	<0.001
	Bombus fervidus	4.013	2.783	0.005
	Bombus perplexus	1.905	2.432	0.015
	Bombus vagans	2.122	2.653	0.008
Apicystis bombi	Cranberry acreage	-0.009	-0.719	0.472
	Date of catch	-0.018	-2.166	0.030
Conopid flies	Cranberry acreage	-0.006	-0.953	0.341
	Bombus impatiens	1.157	2.495	0.013

Table 1. Logistic regression was used to test the relationship between parasite prevalence and a number of factors, including the acreage of cranberry within 2 km around individual bees, date of catch, and species. The effect of cranberry acreage on parasite prevalence is listed along with any significant factors found in the model.

Acreage of cranberry around bees appears to have a negative relationship with the prevalence of *Crithidia bombi*.

Parasite	Factors	Estimate	z-score	P-value
Crithidia bombi	Cranberry acreage	-0.032	-1.324	0.055
	Date of catch	-0.000	-0.000	0.001
Nosema bombi	Cranberry acreage	0.016	1.415	0.157
	Date of catch	0.092	2.566	0.010
	Sample type Fecal	-1.057	-1.932	0.053
	Sample type Gut	-2.282	-1.725	0.085

Table 2. A similar analysis was undertaken with the queens using the same factors. The effect of cranberry acreage on parasite prevalence is listed along with any significant factors found in the model. Infection rates by *Apicysitis bombi* and conopid flies were too low for analysis.
There does not appear to be any strong correlation between cranberry acreage and parasite prevalence in queens.

Parasite	Estimate	z-score	P-value
Crithidia	-0.034	**-2.024**	**0.043**
Nosema	-0.001	-0.021	0.983
Apicystis	-0.002	-0.429	0.668

Table 3. Pathogen intensities in bumble bees of all species caught were ranked from levels ranging from 1-6. Rank bins were from 0-10, 11-100, 101-500, 501-1000, and 1000+. Ranks were compared to the percent of the landscape surrounding individuals within 2 km that is considered cranberry bog.

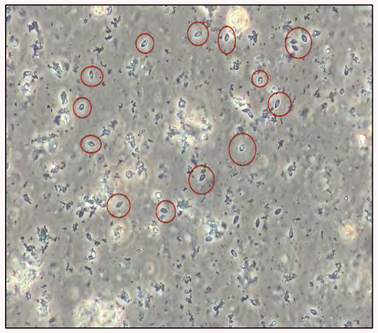
Intensity of parasitism by *Crithidia bombi* is related to the acreage of surrounding cranberry.

Potential explanations and implications

- Due to the collections of bumble bees off-bog, they may not have been as exposed to agricultural inputs as bees that are found on-bog, and may also have a wider breadth of plants to forage from.
- Fungicide application has been linked to higher risk of *Nosema* infection in honey bees. Might agricultural inputs be interacting with *Crithidia* in a different way?
- Some phytochemicals, such as anabasine, eugenol, and thymol have been found to inhibit *Crithidia bombi* growth. Could some of the flavonoids, phenolic acids, or terpenes found in cranberry have a similar effect on *Crithidia*?
- Nevertheless, it is interesting that surrounding cranberry acreage has an effect on the prevalence and intensity of *Crithidia bombi*. Controlled lab and field trials would be necessary to further understand the relationship.

Parasites

Crithidia bombi (Order: Trypanosomatida)

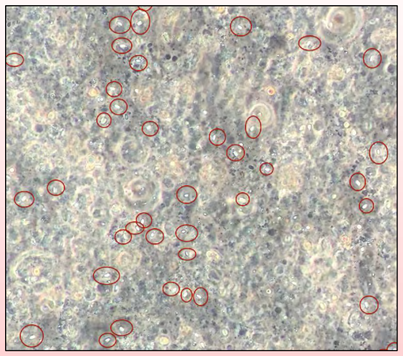


Trypanosome protozoa.

Transmitted through feces.

Affects reproductive fitness of *Bombus* queens. Workers less likely to forage for pollen.

Nosema bombi (Order: Dissociodihaplophasida)

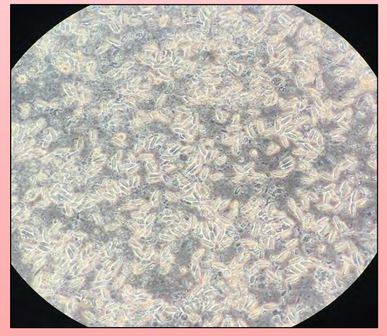


Fungus, microsporidian.

Transmitted between colonies from workers sharing infected pollen and nectar.

Infected queens produce smaller colonies. Affects survival of workers and males.

Apicystis bombi (Order : Neogregarinorida)

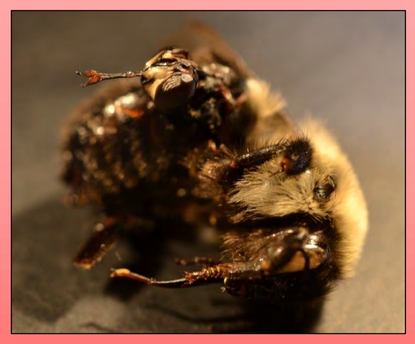


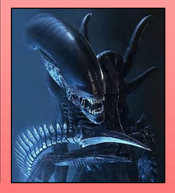
Parasitic alveolate.

Transmission through ingestion; resides and multiplies in fat body cells.

Both lethal and sublethal effects, increased mortality, reduced fat body, sensitivity to sucrose

Conopid flies, Thick-headed fly (Order: Diptera)





Just like our favorite monster in Ridley Scott's Alien!

Parasitoid fly: Adult lays eggs in bee's abdomen. Larvae ingest abdomen and emerge as adult flies.
Likely of the genus *Physocephala*.

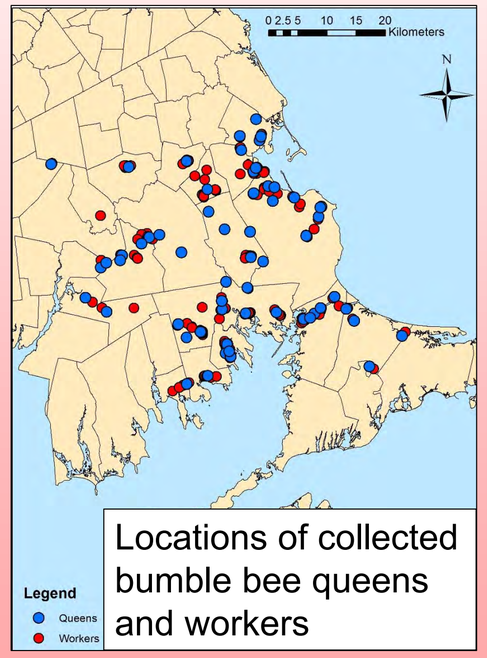
Collection and Assessment

Dissected midguts and fat bodies of bees

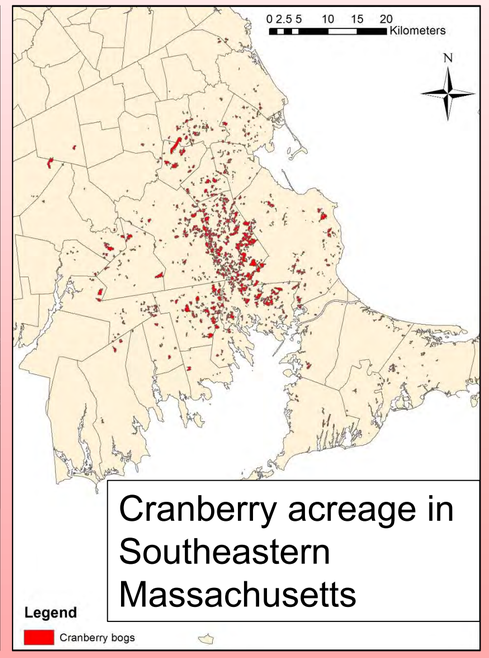
Bumble bee queens and workers were collected by hand at over 200 **off-bog** locations across southeastern Massachusetts in 2015.

Midgut of workers were assessed for parasites. Either midgut, fecal samples, or both from queens were assessed.

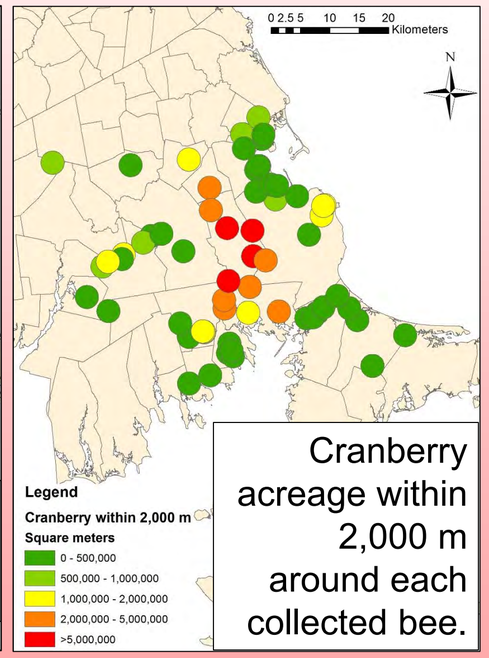
Bees were identified and prevalence (Y/N) and intensity (# of individuals, if possible) of parasitism were recorded



Locations of collected bumble bee queens and workers



Cranberry acreage in Southeastern Massachusetts



Cranberry acreage within 2,000 m around each collected bee.

Acknowledgements and References

We would like to thank the numerous summer employees who drove around the wilds of southeastern Massachusetts chasing and collecting bumble bees.

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